

## C5. CHAPTER 5

### CONSTRUCTION CRITERIA PERMITTING REDUCED SEPARATION DISTANCES

#### C5.1. GENERAL

C5.1.1. This chapter contains DoD standards for construction of ECM, barricades, barricaded open storage modules, special structures, ARMCO, Inc. revetments, and underground storage facilities. Facilities constructed per this chapter:

C5.1.1.1. Are permitted to use reduced separation distance criteria.

C5.1.1.2. Must meet the criteria of Chapters 6 and 7.

C5.1.2. Construction features and location are important safety considerations in planning facilities. The effects of potential explosions may be altered significantly by construction features that limit the amount of explosives involved, attenuate blast overpressure or thermal radiation, and reduce the quantity and range of hazardous fragments and debris. (NOTE: Proper location of ES in relation to PES helps minimize unacceptable damage and injuries in the event of an incident.) The major objectives in facility planning shall be to:

C5.1.2.1. Protect against explosion propagation between adjacent bays or buildings and protect personnel against death or serious injury from incidents in adjacent bays or buildings. The construction of separate buildings to limit explosion propagation, rather than the use of either protective construction or separation of explosives within a single building should be considered when safety would be greatly enhanced or cost would be significantly reduced.

C5.1.2.2. Protect assets, when warranted.

C5.1.3. *Protective construction, such as H*hardening an ES or constructing a PES to suppress explosion effects, to provide an appropriate degree of protection may allow a reduction of the separation distances required by QD tables. The rationale and supporting data that justify any such QD reduction shall be submitted to the DDESB with the site and general construction plans for approval (see section C5.4.).

C5.1.4. New construction of previously DDESB-approved 7-Bar and 3-Bar ECM must meet the minimum requirements of the current revisions of the approved drawings.

#### C5.2. AE STORAGE FACILITIES

C5.2.1. ECM. An ECM's primary purpose is to protect AE. To qualify for the default IMD in Table C9.T6., an ECM, acting as an ES, must not collapse. Although substantial permanent deformation of the ECM may occur, sufficient space should be provided to prevent the deformed structure or its doors from striking the contents.

C5.2.1.1. ECM may be approved for storage of up to 500,000 lbs NEW [226,795 kg NEQ] of HD 1.1 in accordance with (IAW) Table C9.T5. DDESB TP No. 15 (Reference (j)) provides listings of the various types of ECM that have been constructed. These magazines are identified by their structural strength designator (i.e. 7-Bar, 3-Bar, or Undefined). Table AP1-1. of Reference (j) lists the 7-Bar and 3-Bar ECM designs that are currently approved for new construction.

C5.2.1.1.1. If an ECM's drawing number(s) are not listed in Reference (j), it shall be treated as an "Undefined" ECM, until a structural analysis is performed to show that the ECM qualifies for another structural strength designation, or support documentation is provided to prove the ECM had been approved by the DDESB with a different structural strength designation.

C5.2.1.1.2. For existing, arch-shaped Undefined ECM, U. S. Army Corps of Engineers (CoE) Report HNDED-CS-S-95-01 (Reference (k)) may be used to determine if an Undefined ECM could qualify as a 7-Bar or a 3-Bar ECM.

C5.2.1.1.3. DDESB approval is required prior to any change in an ECM's structural strength designator.

C5.2.1.1.4. Certain ECM, aboveground storage magazines, and containers have been approved with reduced NEW and/or reduced QD and these are listed in Table AP1-4. of Reference (j). Use of these structures/containers requires that their use and siting meet all conditions AND restrictions specified in the design and approval documentation, as described in Reference (j).

C5.2.1.2. ECM must be designed to withstand the following:

C5.2.1.2.1. Conventional (e.g., live, dead, snow) loads for the barrel of an arch-shaped ECM.

C5.2.1.2.2. Conventional (e.g., live, dead, snow) and blast-induced loads for the roof of a flat-roofed ECM.

C5.2.1.2.3. Conventional (e.g., live, dead, snow) loads for the rear wall of an arch-shaped ECM and for the rear and side walls of a flat-roofed ECM.

C5.2.1.2.4. Expected blast loads, as applicable:

C5.2.1.2.4.1. On the head wall and door of 3-Bar ES ECM is a triangular pulse with peak overpressure of 43.5 psi [3 bars, 300 kPa] and impulse of  $11.3W^{1/3}$  psi-ms [ $100Q^{1/3}$  Pa-s].

C5.2.1.2.4.2. On the head wall and door of 7-Bar ES ECM is a triangular pulse with peak overpressure of 101.5 psi [7 bars, 700 kPa] and impulse of  $13.9W^{1/3}$  psi-ms [ $123Q^{1/3}$  Pa-s].

C5.2.1.2.4.3. On the roof of a flat-roofed Undefined, 3-Bar, or 7-Bar ES ECM is a triangular pulse with peak overpressure of 108 psi [7.5 bars, 745 kPa] and impulse of  $19W^{1/3}$  psi-ms [ $170Q^{1/3}$  Pa-s].

#### C5.2.1.3. Earth cover for ECM.

C5.2.1.3.1. Earth cover shall be reasonably cohesive and free from harmful (toxic) matter, trash, debris, and stones heavier than ten pounds [4.54 kg] or larger than six inches [152 mm] in diameter. Solid or wet clay or similar types of soil shall not be used as earth cover because it is too cohesive. The larger of acceptable stones shall be limited to the lower center of fills and shall not be used for earth cover over magazines. The earthen material shall be compacted and prepared, as necessary, for structural integrity and erosion control. If it is impossible to use a cohesive material (e.g., in sandy soil), the earth cover over ECM shall be finished with a suitable material (e.g., geotextiles, gunnite) that will ensure structural integrity.

C5.2.1.3.2. The earth fill or earth cover between ECM may be either solid or sloped. A minimum of 2 ft [0.61 m] of earth cover shall be maintained over the top of each ECM. If the specified thickness and slope of earth on the ECM is not maintained, the ECM shall be sited as an AGM.

#### C5.2.2. Barricaded Open Storage Modules

C5.2.2.1. As depicted in Figure C5.F1., a module is a barricaded area composed of a series of connected cells with hard surface (e.g., concrete, packed earth, engineered materials, etc.) storage pads separated from each other by barricades. Although a light metal shed or other lightweight fire retardant cover may be used for weather protection for individual cells, heavy structures (e.g., reinforced concrete, dense masonry units), or flammable material shall not be used.

C5.2.2.2. The maximum NEW [NEQ] permitted to be stored within each cell is 250,000 lbs [113,398 kg].

C5.2.2.3. Module storage is considered a temporary expedient and may be used as the DoD Component concerned determines necessary. However, from an explosives safety and reliability standpoint, priority shall be given to the use of ECM for items requiring protection from the elements, long-term storage, or high security protection.

C5.2.2.4. Storage shall be limited to AE that will not promptly propagate explosions or mass fire between modules, and that are not susceptible to firebrands and fireballs. These restrictions allow storage at K1.1 [0.44] separation.

C5.2.2.4.1. Only the following AE are approved for modular storage:

C5.2.2.4.1.1. ~~Robust HD 1.1 AE (e.g., HE bombs, (fuzed or unfuzed, with or without fins)~~ *and similarly cased HD 1.1 AE*, when stored on nonflammable pallets.

C5.2.2.4.1.2. The below items when contained in nonflammable shipping containers:

C5.2.2.4.1.2.1. 30 mm and smaller AE.

C5.2.2.4.1.2.2. CBU.

C5.2.2.4.1.2.3. Inert AE components.

C5.2.2.4.1.2.4. HD 1.4 AE.

C5.2.2.4.2. Module storage of AE items in flammable outer-packaging configurations shall be minimized. AE items in flammable outer-packaging configurations must be covered with fire retardant material. Combustible dunnage or other flammable material shall not be stored either in, or within, 100 ft [30.5 m] of modules.

C5.2.2.4.3. When fire retardant materials are used to cover AE items stored in modules, ventilation shall be provided between the covers and the stored AE items to minimize the effects of solar heating upon the stored AE.

C5.2.2.4.4. AE stored in each module shall normally be limited to one type of item, unless the DoD Component concerned authorizes mixed storage.

C5.2.2.5. Barricade Requirements:

C5.2.2.5.1. All barricades used in forming the module shall meet the requirements in section C5.3. The width or length of the stack of AE (controlled by the pad size of the cell) and the distances between the stack and the top of the barricade influences the minimum barricade height requirement. The heights listed in Table C5.T1. are the minimum requirements for barricade locations. These minimum heights are based upon both the storage pad sizes and the separations shown. When feasible, barricade heights should be increased ~~(see subparagraph C5.3.2.3.)~~.

C5.2.2.5.2. The centerlines of barricades between cells of the module shall be located at a point halfway between adjacent AE storage pads. Back and end (outside) barricades shall be located at the same distance from the pads as those between the cells.

C5.2.2.5.3. When selecting a site for a module, maximum advantage should be taken of natural topographical barriers. When used, natural barriers shall provide the same level of protection as the barricade shown in Figure C5.F1.

C5.2.2.6. Table C5.T1. provides the minimum pad sizes necessary to store the NEWQD indicated. The pad's size may need to be adjusted to accommodate specific AE. This adjustment will impact the required barricade height (see Note 2 of Table C5.T1.).

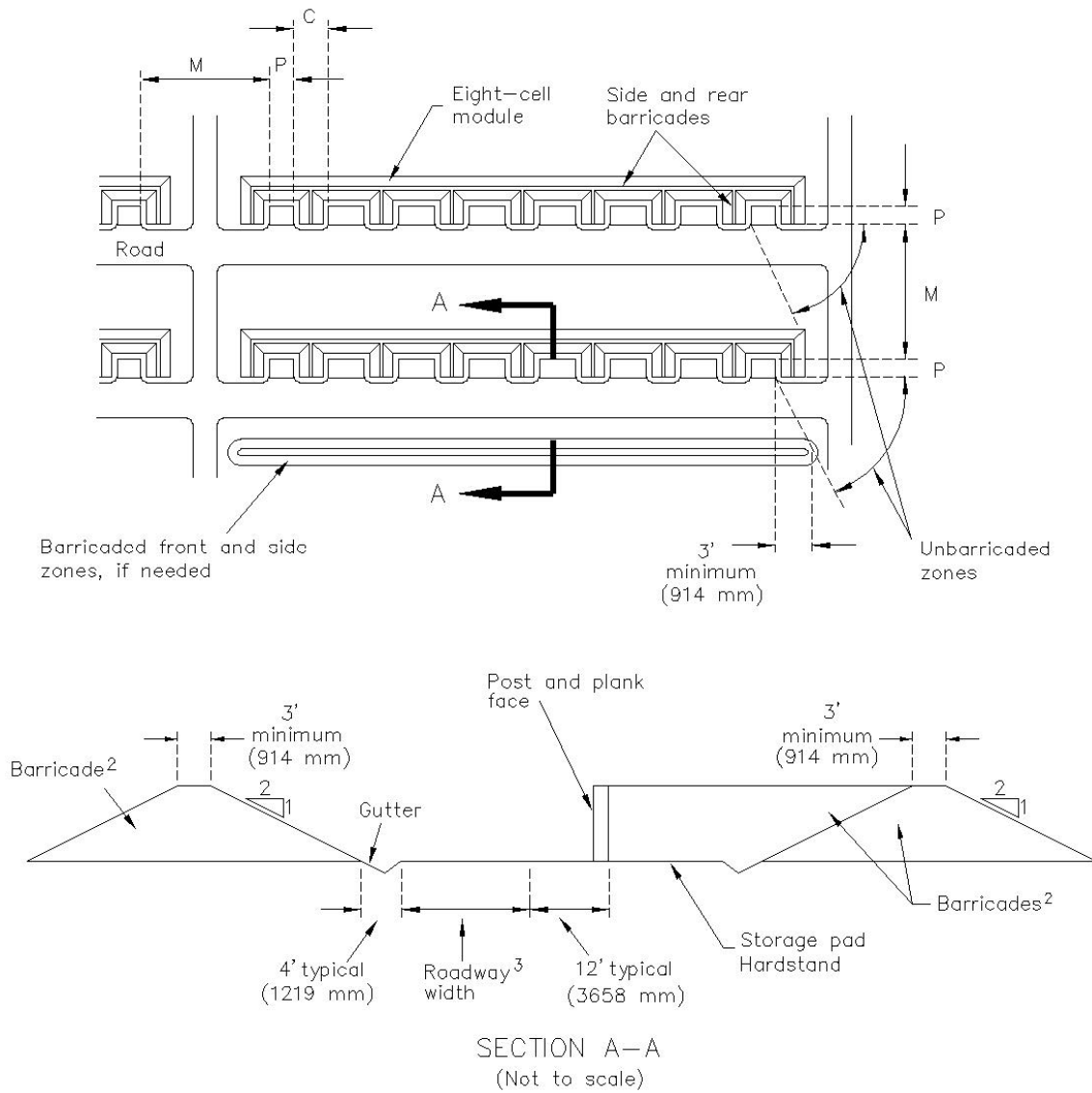
C5.2.2.7. The only restriction on the arrangement of cells within a module and of groups of modules is that cell openings may not face each other, unless they are either barricaded or meet QD criteria for an unbarricaded AGM (see Table C9.T6.).

### C5.2.3. Underground Storage Facilities

#### C5.2.3.1. General Design Considerations

C5.2.3.1.1. Underground storage facilities may consist of a single chamber or a series of connected chambers and other protective construction features. The chambers may be either excavated or natural geological cavities. Figure C5.F2. shows the layout of several typical underground facilities. To qualify as an underground facility, the minimum distance from the perimeter of a storage area to an exterior surface shall be greater than  $0.25 W^{1/3}$  [ $0.10 Q^{1/3}$ ]. This minimum distance normally, but not always, equals the thickness of the earth cover. If this criterion cannot be met, the facility must be sited as an AGM.

C5.2.3.1.2. Design of new underground storage facilities must take into account site conditions, storage requirements, and operational needs. Once these are established, a design may be developed based on the CoE definitive drawing, DEF 421-80-04, discussed in Chapter 5 of Reference (j). Special features (e.g., debris traps, expansion chambers, closure blocks, portal barricades, and constrictions) may be incorporated in the design of underground storage facilities to reduce the IBD for both debris and airblast. The specifications for these special features are also given in CoE definitive drawing, DEF 421-80-04, and their effects are discussed below.

Figure C5.F1. Typical Eight-Cell Open Storage Module (see paragraph C5.2.2.)**Notes for Figure C5.F1.:**

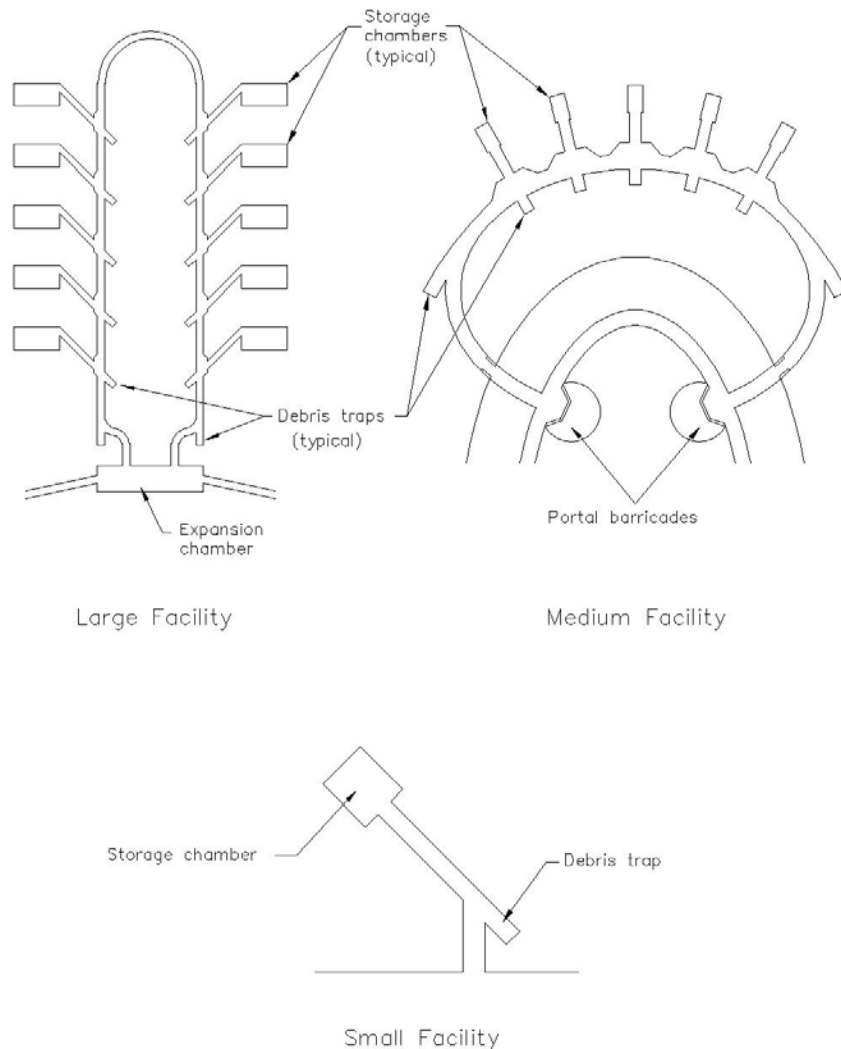
1. Number of cells, cells' NEWQD, pad sizes (P), distances between cells (C) and modules (M), and minimum barricade heights can vary (see Table C5.T1.).
2. Refer to section C5.3. for barricade design criteria and for alternate barricade designs.
3. Roadway width determined by the DoD Components.

Table C5.T1. HD 1.1 IMD for Barricaded Open Storage Module

NEWQD	Minimum Pad-to-Pad Separation Distance ("C" and "M" in C5.F1) <sup>1,2</sup>	Maximum Pad Dimension ("P" in C5.F1) Width or Depth	Minimum Height Above Top of Stack <sup>3</sup>
(lbs) [kg]	(ft) [m]	(ft) [m]	(ft) [m]
50,000	41	30	2
22,680	12.5	9.1	0.6
70,000	45	30	2
31,751	13.9	9.1	0.6
100,000	51	30	2
45,359	15.7	9.1	0.6
150,000	58	30	2
68,039	18.0	9.1	0.6
200,000	64	30	2
90,718	19.8	9.1	0.6
200,000	64	40	2.5
90,718	19.8	12.2	0.8
250,000	69	40	2.5
113,398	21.3	12.2	0.8
250,000	69	50	3
113,398	21.3	15.2	0.9

Notes for Table C5.T1.:

- $D = 1.1W^{1/3}$   
 D in ft and W in lbs [English EQN C5.T1-1]  
 $D = 0.44Q^{1/3}$   
 D in m and Q in kg [Metric EQN C5.T1-2]  
 $W = D^3/1.33$   
 W in lb and D in ft [English EQN C5.T1-3]  
 $Q = D^3/0.083$   
 Q in kg and D in m [Metric EQN C5.T1-4]
- AE shall not be stored beyond the boundaries of the storage pad.
- Barricade height is based upon storage pad size. When "P" exceeds 50 ft [15.2 m], then the barricade height shall be increased by 6 inches [152 mm] for each 10 ft [3.05 m] increase of "P."

Figure C5.F2. Typical Underground Storage Facilities (see paragraph C5.2.3.)

### C5.2.3.2. Special Design Considerations

C5.2.3.2.1. Debris Mitigation. Debris IBD may be reduced through the use of debris traps, expansion chambers, high pressure closures, and portal barricades.

C5.2.3.2.1.1. Debris traps are pockets excavated in the rock at or beyond the end of sections of tunnel that are designed to catch debris from a storage chamber detonation. Debris traps should be at least 20 percent wider and 10 percent taller than the tunnel leading to the trap, with a depth (measured along the shortest wall) of at least one tunnel diameter.

C5.2.3.2.1.2. Expansion chambers are very effective in entrapping debris, as long as the tunnels entering and exiting the chambers are either offset in axial alignment by at least two tunnel widths, or enter and exit the chambers in directions that differ by at least 45 degrees.

C5.2.3.2.1.3. To be effective, debris traps and expansion chambers that are intended to entrap debris must be designed to contain the full potential volume of debris, based on the maximum capacity of the largest storage chamber.

C5.2.3.2.1.4. Portal barricades provide a means of reducing IBD from debris by obstructing the path of the debris as it exits the tunnel.

C5.2.3.2.1.5. High-pressure closures are large blocks constructed of concrete or other materials that can obstruct or greatly reduce the flow of blast effects and debris from an explosion from or into a storage chamber. For chamber loading density ( $w$ ) of about 0.625 lb/ft<sup>3</sup> [10 kg/m<sup>3</sup>] or above, closure blocks will contain 40 percent or more of the explosion debris within the detonation chamber, provided that the block is designed to remain intact. If a closure block fails under the blast load, it will produce a volume of debris in addition to that from the chamber itself. However, because the block's mass and inertia are sufficient to greatly reduce the velocity of the primary debris, the effectiveness of other debris-mitigating features (e.g., debris traps, expansion chambers, and barricades) is increased.

C5.2.3.2.1.6. Use of barricades with any other of these features will lower the debris hazard to a level where QD considerations for debris is not required.

C5.2.3.3. Airblast Mitigation. Special features that may be used in underground storage facilities to reduce airblast IBD include:

C5.2.3.3.1. Facility Layouts. A facility's layout and its volume control the external airblast effects.

C5.2.3.3.1.1. In a single-chamber facility with a straight access tunnel leading from the chamber to the portal, which is commonly called a "shotgun" magazine, the blast and debris are channeled to the external area as if fired from a long-barreled gun. In this type of facility design, airblast mitigation, given a fixed NEWQD, can be provided by increased chamber and tunnel dimensions.

C5.2.3.3.1.2. In more complex facility layouts, reflections of the explosive shock against the various tunnel walls may reduce the exit pressures. The cumulative effects of these reflections may reduce the overpressure at the shock front to that of the expanding gas pressure. In addition, the detonation gas pressure decreases as the volume it occupies increases. Therefore, larger, more complex facilities will produce greater reductions in the effective overpressure at the opening, which will reduce the IBD.

C5.2.3.3.1.3. In a more complex facility with two or more openings, the IBD will be reduced by about 10 percent.

C5.2.3.3.2. Expansion-Chambers. Expansion-chambers provide additional volume for the expansion of the detonation gasses behind the shock front as it enters the chamber from a connecting tunnel. Some additional reduction of the peak pressure at the shock front occurs as the front expands into the expansion-chamber and reflects from the walls. Although expansion-

chambers may be used as loading areas or as turn-around areas for transport vehicles servicing facilities through a single entry passage, they shall not be used for storage.

C5.2.3.3.3. Constrictions. Constrictions are short lengths of tunnel whose cross-sectional areas are reduced to one-half or less of the normal tunnel cross-section. Constrictions reduce the airblast effects passing through them. To be effective, constrictions should be placed within five tunnel diameters of the tunnel exit or to the entrances of storage chambers. As an added benefit, constrictions at chamber entrances also reduce the total loading on blast doors that may be installed to protect a chamber's contents.

C5.2.3.3.4. Portal Barricades. A barricade in front of the portal (entrance into tunnel) will reflect that portion of the shock wave moving directly outward from the portal, thereby reducing the pressures along the extended tunnel axis and increasing the pressures in the opposite direction. The result is a more circular IBD area centered at the portal. A portal barricade meeting the construction criteria of the CoE definitive drawing discussed in subparagraph C5.2.3.1.2. will reduce the IBD along the extended tunnel axis by 50 percent. The total IBD area is only slightly reduced, but will change to a circular area, half of which is behind the portal.

C5.2.3.3.5. High-Pressure Closures. High-Pressure Closures are large blocks constructed of concrete or other materials that obstruct or greatly reduce the flow of blast effects and debris from an explosion from or into a storage chamber.

C5.2.3.3.5.1. When used to reduce QD, by restricting the blast outflow from a chamber, the block must be designed to be rapidly driven from an open to a closed position by the detonation pressures in the chamber. While this type of block will provide some protection of chamber contents from an explosion in another chamber, blast doors must also be used to provide complete protection. Tests have shown that a closure block, with sufficient mass, can obstruct the initial outflow of airblast from an explosion in a chamber to reduce pressures in the connecting tunnels by a factor of two or more, even when the block is destroyed. Blocks with sufficient strength to remain structurally intact can provide greater reductions. Because many variables influence the performance of a closing device, their design details must be developed on a site-specific basis.

C5.2.3.3.5.1.1. For loading densities ( $w$ ) of  $0.625 \text{ lb/ft}^3$  [ $10 \text{ kg/m}^3$ ] or higher, a 50 percent reduction in IBD may be applied to the use of a high pressure closure block provided it is designed to remain intact in the event of an explosion.

C5.2.3.3.5.1.2. For lower loading densities, use the following reductions:

C5.2.3.3.5.1.2.1.  $0.0625 < w < 0.625 \text{ lb/ft}^3$  [ $1.0 < w < 10 \text{ kg/m}^3$ ],  
reductions may be calculated by:

$$y(\%) = 50 \log_{10}(16.02w) \quad [\text{English EQN C5.2-1}]$$

$$[y(\%) = 50 \log_{10}(1.0w)] \quad [\text{Metric EQN C5.2-2}]$$

where  $y$  is the percent reduction in IBD, and  $w$  is loading density in  $\text{lb/ft}^3$  [ $\text{kg/m}^3$ ]

C5.2.3.3.5.1.2.2. For  $w < 0.0625 \text{ lb/ft}^3$  [ $w < 1 \text{ kg/m}^3$ ]:  
 $y(\%) = 0$ .

C5.2.3.3.6. When used to protect the contents of a chamber from an explosion in another chamber, the block must be designed to move from a normally closed position to an open position when entry is required. Blast doors are not required for this type of closure block.

C5.2.3.4. Chamber Separation Requirements. Minimum storage chamber separation distances are required to prevent or control the communication of explosions or fires between chambers. There are three modes by which an explosion or fire can be communicated: rock spall, propagation through cracks or fissures, and airblast or thermal effects traveling through connecting passages. Spalled rock of sufficient mass that is traveling at a sufficient velocity may damage or sympathetically detonate impacted AE in the acceptor chambers.

C5.2.3.4.1. Prevention of Damage by Rock Spall (HD 1.1 and HD 1.3). The chamber separation distance is the shortest distance (rock thickness) between two chambers. When an explosion occurs in a donor chamber (a PES), a shock wave is transmitted through the surrounding rock. The intensity of the shock decreases with distance. For small chamber separation distances, the shock may be strong enough to produce spalling of the rock walls of adjacent ES chambers. When no specific protective construction is used:

C5.2.3.4.1.1. For moderate to strong rock, with loading densities less than or equal to  $3.0 \text{ lb/ft}^3$  [ $48.1 \text{ kg/m}^3$ ], the minimum chamber separation distance ( $D_{cd}$ ) required to prevent hazardous spall effects is:

$$D_{cd} = 2.5W^{1/3} \quad [\text{English EQN C5.2-3}]$$

$$[D_{cd} = .99Q^{1/3}] \quad [\text{Metric EQN C5.2-4}]$$

where  $D_{cd}$  is in ft and  $W$  is in lbs [ $D_{cd}$  is in m, and  $Q$  is in kg]. (NOTE:  $D_{cd}$  shall not be less than 15 ft [4.6 m].)

C5.2.3.4.1.1.1. For loading densities greater than  $3.0 \text{ lbs/ft}^3$  [ $48 \text{ kg/m}^3$ ], the separation distance is:

$$D_{cd} = 5.0W^{1/3} \quad [\text{English EQN C5.2-5}]$$

$$[D_{cd} = 1.98Q^{1/3}] \quad [\text{Metric EQN C5.2-6}]$$

C5.2.3.4.1.2. For weak rock, at all loading densities, the separation distance is:

$$D_{cd} = 3.5W^{1/3} \quad [\text{English EQN C5.2-7}]$$

$$[D_{cd} = 1.39Q^{1/3}] \quad [\text{Metric EQN C5.2-8}]$$

C5.2.3.4.1.3. The equations above are the basis for values of  $D_{cd}$  listed in Table C5.T2.).

C5.2.3.5. Prevention of Propagation by Rock Spall (HD 1.1 and HD 1.3). Because rock spall is considered an immediate mode of propagation, time separations between donor and acceptor explosions may not be sufficient to prevent coalescence of blast waves. If damage to AE stored in adjacent chambers is acceptable, chamber separation distances from those determined to prevent damage (see subparagraph C5.2.3.2.1.) can be reduced to prevent propagation by rock spall. To prevent propagation, the separation distances between donor and

acceptor chambers are calculated using the below equations. If the required separation distances defined below cannot be met, explosives weights in all chambers must be added together to determine  $W$ , unless analyses or experiments demonstrate otherwise.

C5.2.3.5.1. When no special protective construction is used, the separation distance ( $D_{cp}$ ) to prevent propagation by rock spall is:

$$D_{cp} = 1.5W^{1/3} \quad [\text{English EQN C5.2-9}]$$

$$[D_{cp} = 0.59Q^{1/3}] \quad [\text{Metric EQN C5.2-10}]$$

where  $D_{cp}$  is in ft and  $W$  is in lbs. [ $D_{cp}$  is in m and  $Q$  is in kg]

C5.2.3.5.2. When the acceptor chamber has protective construction to prevent spall and collapse, the  $D_{cp}$  to prevent propagation by impact of rock spall is:

$$D_{cp} = 0.75W^{1/3} \quad [\text{English EQN C5.2-11}]$$

$$[D_{cp} = 0.30Q^{1/3}] \quad [\text{Metric EQN C5.2-12}]$$

where  $D_{cp}$  is in ft and  $W$  is in lbs. [ $D_{cp}$  is in m and  $Q$  in kg]

C5.2.3.5.3. Separation distances,  $D_{cp}$  and  $D_{cd}$ , are listed in Table C5.T2. These distances are based on an explosive loading density of 17 lb/ft<sup>3</sup> [272.3 kg/m<sup>3</sup>] and will likely be safety conservative for lower loading densities.

C5.2.3.6. Prevention of Propagation Through Cracks and Fissures (HD 1.1 and HD 1.3). Propagation between a donor and an acceptor chamber has been observed to occur when natural, near-horizontal jointing planes, cracks, or fissures in the rock between the chambers are opened by the lifting force of the detonation pressure. Prior to construction of a multi-chamber magazine, a careful site investigation must be made to ensure that such joints or fissures do not extend from one chamber location to an adjacent one. Should such defects be encountered during facility excavation, a reevaluation of the intended siting is required.

C5.2.3.7. Prevention of Propagation through Passageways (HD 1.1 and HD 1.3). Flame and hot gas may provide a delayed mode of propagation. Time separations between the events in the donor chamber and the acceptor chamber by this mode will likely be sufficient to prevent coalescence of blast waves. Consequently, siting is based on each chamber's NEWQD. To protect assets, blast and fire resistant doors may be installed within multi-chambered facilities. Evaluations for required chamber separations due to this propagation mode should be made on a site-specific basis using procedures outlined in CoE definitive drawing DEF 421-80-04. For HD 1.1 and HD 1.3 materials:

C5.2.3.7.1. Chamber entrances at the ground surface, or entrances to branch tunnels off the same side of a main passageway, shall be separated by at least 15 ft [4.6 m].

C5.2.3.7.2. Entrances to branch tunnels off opposite sides of a main passageway shall be separated by at least twice the width of the main passageway.

C5.2.3.8. Chamber Cover Thickness. The chamber cover thickness is the shortest distance between the ground surface and the natural rock surface at the chamber's ceiling or, in

some cases, a chamber's wall. For all types of rock, the critical cover thickness required to prevent breaching of the chamber cover by a detonation ( $C_c$ ) is

$$C_c = 2.5W^{1/3}$$

[English EQN C5.2-13]

$$[C_c = .99Q^{1/3}]$$

[Metric EQN C5.2-14]

where  $C_c$  is in ft and  $W$  is in lbs [ $C_c$  is in m and  $Q$  is in kg].

Table C5.T2. Chamber Separation Distances Required to Prevent Damage and Propagation by Rock Spall

NEWQD	Chamber Separation to Prevent Damage by Rock Spall, $D_{cd}$			Chamber Separation to Prevent Propagation by Rock Spall, $D_{cp}$	
	Moderate-to-strong rock		Weak rock (all loading densities)	No protective construction	With protective construction
	$w \leq 3 \text{ lbs/ft}^3$	$w > 3 \text{ lbs/ft}^3$			
	$w \leq 48.1 \text{ kg/m}^3$	$w > 48.1 \text{ kg/m}^3$			
	(See note 1)	(See note 2)	(See note 3)	(See note 4)	(See note 5)
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)
[kg]	[m]	[m]	[m]	[m]	[m]
1,000	25	50	35	15.0	7.5
454	7.6	15.2	10.7	4.6	2.3
2,000	31	63	44	18.9	9.4
907	9.6	19.2	13.5	5.8	2.9
3,000	36	72	50	22	10.8
1,361	11.0	21.9	15.4	6.6	3.3
4,000	40	79	56	24	11.9
1,814	12.1	24.1	17.0	7.3	3.7
5,000	43	85	60	26	12.8
2,268	13.0	26.0	18.3	7.9	3.9
7,000	48	96	67	29	14.3
3,175	14.6	29.1	20.4	8.8	4.4
10,000	54	108	75	32	16.2
4,536	16.4	32.8	23.0	9.9	5.0
20,000	68	136	95	41	20.4
9,072	20.6	41.3	29.0	12.5	6.3
30,000	78	155	109	47	23.3
13,608	23.6	47.3	33.2	14.3	7.2
50,000	92	184	129	55	27.6
22,680	28.0	56.0	39.3	17.0	8.5
70,000	103	206	144	62	30.9
31,751	31.3	62.7	44.0	19.0	9.5
100,000	116	232	162	70	34.8
45,359	35.3	70.6	49.6	21.4	10.7
200,000	146	292	205	88	43.9
90,718	44.5	89.0	62.5	27.0	13.5
300,000	167	335	234	100	50.2
136,077	50.9	101.8	71.5	30.9	15.4
500,000	198	397	278	119	59.5
226,795	60.4	120.7	84.8	36.6	18.3
700,000	222	444	311	133	66.6
317,513	67.5	135.1	94.8	40.9	20.5
1,000,000	250	500	350	150	75.0
453,590	76.1	152.1	106.8	46.1	23.1

Notes for Table C5.T2.:

- |    |   |                          |
|----|---|--------------------------|
| 1. | $D_{cd} = 2.5W^{1/3}$                                     | [English EQN C5.T2-1]    |
|    | W in lbs, $D_{cd}$ in ft with a minimum distance of 15 ft |                          |
|    | $D_{cd} = 0.99Q^{1/3}$                                    | [Metric EQN C5.T2-2]     |
|    | Q in kg, $D_{cd}$ in m with a minimum distance of 4.57 m  |                          |
|    | $W = D_{cd}^3 / 15.625$                                   | [English EQN C5.T2-3]    |
|    | $D_{cd}$ in ft, W in lbs, with a minimum W of 216 lb      |                          |
|    | $Q = D_{cd}^3 / 0.97$                                     | [Metric EQN C5.T2-4]     |
|    | $D_{cd}$ in m, Q in kg, with a minimum Q of 98.3 kg       |                          |
| 2. | $D_{cd} = 5W^{1/3}$                                       | [English EQN C5.T2-5]    |
|    | W in lbs, $D_{cd}$ in ft with a minimum distance of 15 ft |                          |
|    | $D_{cd} = 1.98Q^{1/3}$                                    | [Metric EQN C5.T2-6]     |
|    | Q in kg, $D_{cd}$ in m with a minimum distance of 4.57 m  |                          |
|    | $W = D_{cd}^3 / 125$                                      | [English EQN C5.T2-7]    |
|    | $D_{cd}$ in ft, W in lbs, with a minimum W of 216 lb      |                          |
|    | $Q = D_{cd}^3 / 7.762$                                    | [Metric EQN C5.T2-8]     |
|    | $D_{cd}$ in m, Q in kg, with a minimum Q of 98.3 kg       |                          |
| 3. | $D_{cd} = 3.5W^{1/3}$                                     | [English EQN C5.T2-9]    |
|    | W in lbs, $D_{cd}$ in ft with a minimum distance of 15 ft |                          |
|    | $D_{cd} = 1.39Q^{1/3}$                                    | [Metric EQN C5.T2-10]    |
|    | Q in kg, $D_{cd}$ in m with a minimum distance of 4.57 m  |                          |
|    | $W = D_{cd}^3 / 42.875$                                   | [English EQN C5.T2-11]   |
|    | $D_{cd}$ in ft, W in lbs, with a minimum W of 216 lb      |                          |
|    | $Q = D_{cd}^3 / 2.686$                                    | [Metric EQN C5.T2-12]    |
|    | $D_{cd}$ in m, Q in kg, with a minimum Q of 98.3 kg       |                          |
| 4. | $D_{cd} = 1.5W^{1/3}$                                     | [English EQN C5.T2-13]   |
|    | W in lbs, $D_{cd}$ in ft                                  |                          |
|    | $D_{cd} = 0.60Q^{1/3}$                                    | [Metric EQN C5.T2-14]    |
|    | Q in kg, $D_{cd}$ in m                                    |                          |
|    | $W = D_{cd}^3 / 3.375$                                    | [English EQN 5 C5.T2-15] |
|    | $D_{cd}$ in ft, W in lb                                   |                          |
|    | $Q = D_{cd}^3 / 0.216$                                    | [Metric EQN C5.T2-16]    |
|    | $D_{cd}$ in m, Q in kg                                    |                          |
| 5. | $D_{cd} = 0.75W^{1/3}$                                    | [English EQN C5.T2-17]   |
|    | W in lbs, $D_{cd}$ in ft                                  |                          |
|    | $D_{cd} = 0.30Q^{1/3}$                                    | [Metric EQN C5.T2-18]    |
|    | Q in kg, $D_{cd}$ in m                                    |                          |
|    | $W = D_{cd}^3 / 0.422$                                    | [English EQN C5.T2-19]   |
|    | $D_{cd}$ in ft, W in lb                                   |                          |
|    | $Q = D_{cd}^3 / 0.027$                                    | [Metric EQN C5.T2-20]    |
|    | $D_{cd}$ in m, Q in kg                                    |                          |

C5.2.4. HPM. HPM allow a reduction in encumbered land by limiting the MCE to a quantity considerably less than that stored in the HPM. (NOTE: HPM are to be constructed per NAVFAC guidance, as outlined in Table AP1-1. of Reference (j), and are to be sited at the IMD provided by Table C9.T6.). HPM separation walls protect against fire propagation between internal storage areas. Although IMD provides nearly complete asset protection between HPM (MCE = 60,000 lbs [27,216 kg] maximum), AE damage may occur to about K9 [3.57] from a donor NEW > 350,000 lbs [158,757 kg].

C5.2.5. AGM. There are no DDESB construction criteria for AGM. However, such structures must meet the criteria of Chapters 6 and 7.

C5.2.6. Special Structures. The DDESB has approved reduced QD for structures and containers listed in Table AP1-4. of Reference (j).

### C5.3. BARRICADES

#### C5.3.1. General

C5.3.1.1. Properly constructed and sited barricades and undisturbed natural earth have explosives safety applications for both protecting against low-angle fragments and reducing shock overpressure loads very near the barricade. Barricades provide no protection against high-angle fragments or lobbed AE. If the barricade is destroyed in the process of providing protection, then secondary fragments from the destroyed barricade must also be considered as part of a hazards analysis.

C5.3.1.2. To reduce hazards from high-velocity, low-angle fragments, the barricade must be placed between the PES and the ES so that the fragments of concern impact the barricade before the ES. The barricade must both be thick enough so that it reduces fragment velocities to acceptable levels and high enough so that it intercepts the ballistic trajectories of the fragments of concern.

C5.3.1.3. A barricade placed between a PES and an ES interrupts the direct line-of-sight motion of the shock wave. If the barricade has sufficient dimensions and is located close enough to the ES, significant reductions in shock loading to selected areas of the ES may be realized.

#### C5.3.2. Barricade Designs

C5.3.2.1. Chapter 6 of Reference (j) lists DDESB-approved designs and construction materials for barricades. Use of these barricades satisfies barricading criteria.

C5.3.2.2. Alternate barricade designs (e.g., earth-filled steel bin) may be approved by the DDESB, provided that testing or analysis demonstrates their effectiveness in stopping high-velocity, low-angle fragments.

C5.3.2.3. Barricade Size and Orientation ~~for Protection Against High Speed, to Prevent Prompt Propagation Due to High-Velocity, Low-Angle Fragments~~. The location, height, and length of a barricade *to prevent prompt propagation due to high-velocity, low-angle fragments* shall be determined as follows:

C5.3.2.3.1. Location. The barricade may be placed anywhere between the PES and the ES; *however, placing it closer to either the PES or ES will provide slightly greater asset protection. For AE stacks of different height (elevation), the location shall determine the barricade's required height-and-length.*

C5.3.2.3.2. Height. To determine the required barricade height:

C5.3.2.3.2.1. Establish a reference point at the top of the far edge of one of the two AE stacks between which the barricade is to be constructed. When both stacks are of equal height, the reference point may be established on either stack. If the tops of the two stacks are not of equal height (elevation), the reference point shall be on the top of the lower stack. To preclude building excessively high barricades *between AE stacks of different height (elevation)*, the barricade should be located as close as possible to the *lower stack* ~~on which the reference point was established~~. (See Figure C5.F3.)

C5.3.2.3.2.2. Draw a line from the reference point to the highest point of the other stack (*line-of-sight*).

~~C5.3.2.3.2.3. Draw a second line from the reference point forming an angle of two degrees above the line. The barricade's height shall be such that the entire width of the barricade crest is at least 1 ft (0.3 m) above the line-of-sight as established in paragraph C5.3.2.3.2.2. The barricade height shall be measured at the time of construction and at intervals throughout the life of the barricade to ensure that the specified thickness and height of the barricade are maintained. If the specified thickness and height of the barricade are not maintained, the AE stack height shall be reduced as necessary or the AE stacks shall be resited appropriately. Consideration should be given to making the barricade higher than required for safety purposes to account for accuracy of storage practices regarding AE stack heights, potential mission changes (requiring higher AE stacks), and barricade settling, erosion, etc., that could seriously degrade AE storage capability.~~

C5.3.2.3.3. Length. The barricade's length shall be determined per Figure C5.F3.

*C5.3.2.4. Barricade Size and Orientation for Barricaded ILD Protection. The location, height, and length of a barricade shall be determined as follows:*

*C5.3.2.4.1. Location. The barricade may be placed anywhere between the PES and the ES. The location shall determine the barricade's required height.*

*C5.3.2.4.2. Height. To determine the required barricade height:*

*C5.3.2.4.2.1. Establish a reference point at the top of the far edge of one of the two AE stacks between which the barricade is to be constructed. When both stacks are of equal height, the reference point may be established on either stack. If the tops of the two stacks are not of equal height (elevation), the reference point shall be on the top of the lower stack. To preclude building excessively high barricades, the barricade should be located as close as possible to the stack on which the reference point was established. (See Figure C5.F4.)*

*C5.3.2.4.2.2. Draw a line from the reference point to the highest point of the other stack.*

*C5.3.2.4.2.3. Draw a second line from the reference point forming an angle of two degrees above the line.*

*C5.3.2.4.3. Length. The barricade's length shall be determined per Figure C5.F4.*

C5.3.2.45. Barricade Size and Orientation for Protection Against Overpressure. General procedures to predict pressure mitigation versus barricade design and location have not been developed. However, based on direct-experimental work, the overpressure loading on a surface area shielded by a barricade is reduced by approximately 50 percent when the following conditions are met:

C5.3.2.45.1. Location. The barricade's standoff is within two barricade heights of the protected area.

C5.3.2.45.2. Height. The top of the barricade is at least as high as the top of the protected area.

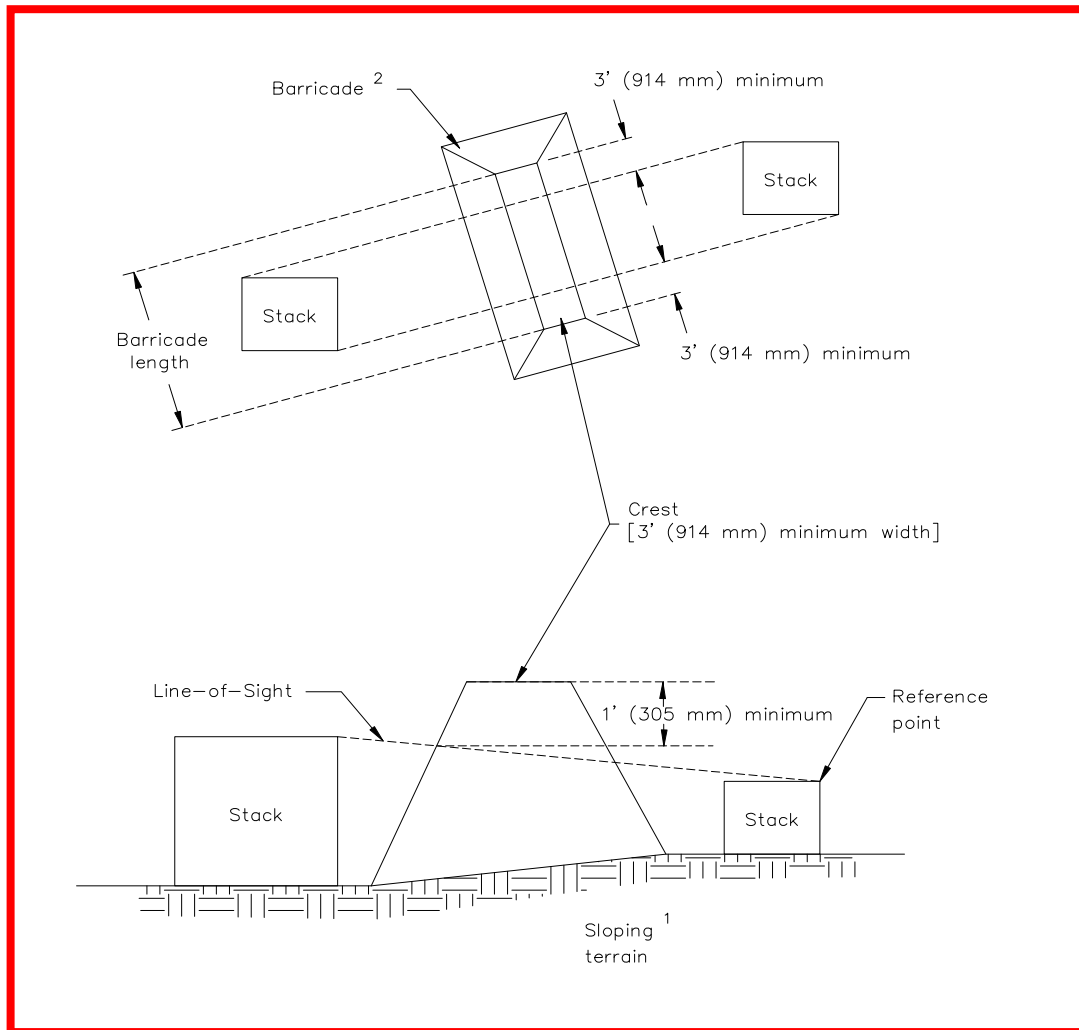
C5.3.2.45.3. Length. The length of the barricade is at least two times the length of the protected area.

#### C5.3.3. Barricade Construction Materials

C5.3.3.1. Materials for earthen barricades shall be reasonably cohesive and free from harmful (toxic) matter, trash, debris, and stones heavier than ten pounds [4.54 kg] or larger than six inches [152 mm] in diameter. The larger of acceptable stones shall be limited to the lower center of fills. Earthen material shall be compacted and prepared, as necessary, for structural integrity and erosion control. Solid or wet clay or similar types of soil shall not be used in barricades because they are too cohesive. If it is impossible to use a cohesive material (e.g., in sandy soil) the barricade shall be finished with a suitable material (e.g., geotextiles, gunnite) that shall not produce hazardous debris, but shall ensure structural integrity.

C5.3.3.2. The slope of an earthen barricade must be two horizontal to one vertical, unless erosion controls are used. Earthen barricades with slopes no greater than one and one half horizontal to one vertical that were approved prior to 1976 may continue to be used. However, renovations to these facilities shall meet the above criteria, when feasible.

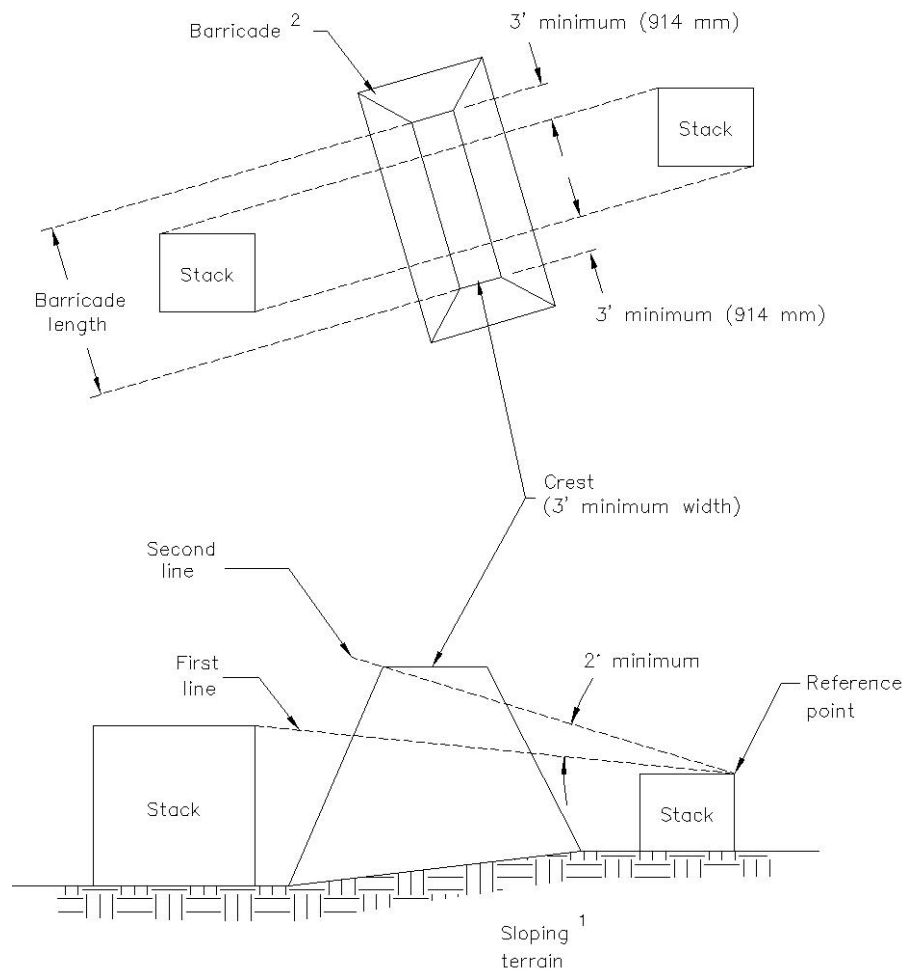
*Figure C5.F3. Determination of Barricade Length and Height to Prevent Prompt Propagation Due to High-Velocity, Low-Angle Fragments  
(See subparagraph C5.3.2.3.)*



*Notes for Figure C5.F3.:*

- 1. This illustration is for sloping terrain; however, a similar approach is used for level terrain.*
- 2. Barricade must meet construction and siting criteria of section C5.3.*

Figure C5.F34. Determination of Barricade Length and Height for ILD Protection  
(See subparagraph C5.3.2.34.)



Notes for Figure C5.F34.:

1. This illustration is for sloping terrain; however, a similar approach is used for level terrain.
2. Barricade must meet construction and siting criteria of section C5.3.

C5.3.4. Portal Barricades for Underground Storage Facilities. Portal barricades allow reduction in IBD for underground magazines. Criteria for the location and construction of portal barricades are illustrated in Figure C5.F45. and include:

C5.3.4.1. Location. Portal (entry or exit) barricades shall be located immediately in front of an outside entrance or exit to a tunnel leading to an explosives storage point. The portal barricade should be centered on the extended axis of the tunnel that passes through the portal and shall be located a distance of not less than one and not more than three tunnel widths from the portal. The actual distance should be no greater than that required (based on the turning radius and operating width) to allow passage of any vehicles or materials handling equipment that may need to enter the tunnel.

C5.3.4.2. Height. The height of the barricade, along its entire width, shall be sufficient to intercept an angle of 10 degrees above the extended height of the tunnel.

C5.3.4.3. Width and Length

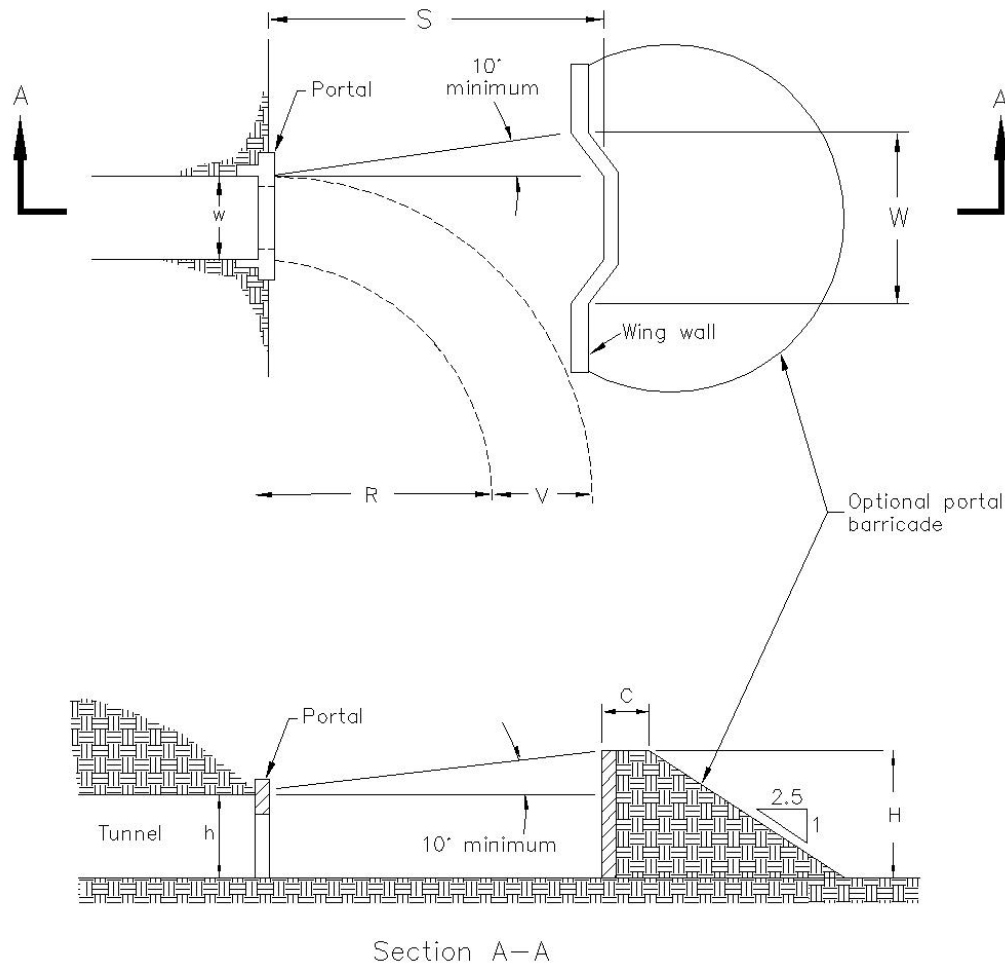
C5.3.4.3.1. The width of the central face typically equals the width of the tunnel at the portal.

C5.3.4.3.2. The front face (i.e., the face toward the entry or exit) shall be vertical and concave in plan view, consisting of a central face oriented perpendicular to the tunnel axis, and wing walls.

C5.3.4.3.3. The wing walls shall be of sufficient width so that the entire barricade length intercepts an angle of 10 degrees (minimum) to the right and left of the extended tunnel width.

C5.3.4.4. Construction. To withstand the impact of debris ejected from the tunnel, the front face (including wing walls) shall be constructed of reinforced concrete, with a minimum thickness equal to 10 percent of the barricade height, but in no case less than 12 inches [30.5 cm]. The concrete wall shall have a spread footing of sufficient width to prevent significant settlement. In addition, the central wall, wing walls, and footing shall be structurally tied together to provide stability. The backfill behind the concrete wall may be composed of any fill material, to include rock rubble from the tunnel excavation, with a maximum particle size of 6 inches [15.2 cm] within the area extending out to 3 feet [0.9 m] from the rear face of the wall.

Figure C5.F45. Portal Barricade Location, Height and Width (see paragraph C5.3.4.)

**Legend for Figure C5.F45.:**

<b>S</b> = Barricade standoff distance from portal	<b>C</b> = Crest width
<b>W</b> = Width of barricade (excluding wing walls)	<b>w</b> = Tunnel width at portal
<b>H</b> = Height of barricade	<b>h</b> = height of tunnel
<b>V</b> = Width of munitions transport vehicles	
<b>R</b> = Turning radius of munitions transport vehicles	

**C5.3.5. Earth-Filled, Steel Bin-Type Barricades (ARMCO Revetments or Equivalent) for Outside Storage**

C5.3.5.1. These barricades, also known as ARMCO, Inc. revetments, are earth-filled steel bins used to separate AE awaiting scheduled processing (e.g., AE on a flight line associated with aircraft parking or loading operations; or the temporary positioning of AE awaiting transfer to preferred, long-term storage). These barricades, which are also used to separate explosive-loaded aircraft, are normally used to form a series of cells. They are designed to limit the MCE, for QD siting purposes, of AE properly positioned in separate cells by preventing prompt detonation transfer to adjacent cells.

C5.3.5.2. ARMCO, Inc. Revetment Cells (see paragraph C6.2.3. of Reference (j)):

C5.3.5.2.1. ARMCO, Inc. revetments cells are approved for storage of any HD 1.1 and HD 1.2 AE assigned to SG 1 through 4, as discussed in paragraph C3.2.3. In addition, storage of HD 1.3, HD 1.4, or HD 1.6 items is approved.

C5.3.5.2.2. When properly sited, these cells prevent prompt detonation transfer; however, all assets in the series of cells are at risk of loss. Although a revetment is effective in limiting the blast loading of an adjacent ES to that produced by the largest contents of a single cell, there is a significant probability that the contents of many of the cells will be damaged or destroyed by the initial and subsequent fire and explosion events. The extent of such losses increases with the amount of explosives present.

C5.3.5.3. Types of ARMCO, Inc. Revetments

C5.3.5.3.1. Type A revetments, which must be a minimum of 7 feet [2.1 m] thick, can be used to limit a MCE in a series of cells to the largest quantity in a single cell, provided the quantity in the single cell does not exceed 30,000 pounds NEW [NEQ] [13,608 kg].

C5.3.5.3.2. Type B revetments, which must be a minimum of 5.25 feet [1.6 m] thick, can be similarly used to limit the MCE, provided no cell contains more than 5,000 pounds NEW [2,268 kg NEQ].

C5.3.5.4. For ARMCO, Inc. revetments to be used effectively, the following conditions must be met:

C5.3.5.4.1. The criteria shown in Figure C5.F3.

C5.3.5.4.2. AE shall be positioned no closer than 10 feet [3.1 m] from cell walls, no closer than 3 feet [0.9 m] from the end of the wing walls, and no higher than 2 feet [0.6 m] below the top of cell walls.

C5.3.5.4.3. AE shall be distributed over the available area within the cell, rather than being concentrated in a small area.

C5.3.5.4.4. AE stored in a cell in quantities near the maximum NEW limit shall not be configured into a single row of pallets, stacks, or trailers.

C5.3.5.4.5. The storage of AE in flammable outer-pack configurations shall be minimized.

#### C5.4. SITE AND GENERAL CONSTRUCTION PLANS REVIEW

C5.4.1. The following site and general construction plans shall be submitted to the DDESB for review and approval:

C5.4.1.1. New construction of:

C5.4.1.1.1. AE facilities. See Appendix 1 (AP1) for the definition of AE facility.

C5.4.1.1.2. Non-AE related facilities within QD arcs.

C5.4.1.2. Facility modifications, change of mission, or change of operations that increase explosive hazards (e.g., personnel exposures, NEW, change in HD, nature of operation).

C5.4.1.3. Change of use of non-AE related facilities that require application of more stringent explosives safety criteria. (For example, an airfield restricted to DoD use only, changed to joint DoD and non-DoD use.)

C5.4.2. Vulnerable facility construction. Although site plans for construction of vulnerable facilities (e.g., schools, high-rise buildings, restaurants) located on a DoD installation that are outside but near QD arcs are not required, it is recommended that they be submitted to the DDESB for review and comment.

~~—C5.4.3. Site and general construction plans need not be submitted to the DDESB for facility modifications, change of mission, or change of operations that do not introduce additional explosives hazards or do not increase NEW, chemical agent hazards, or personnel exposure.~~

#### C5.4.43. Site Plan Submission Requirements

C5.4.43.1. Preliminary. When required by the DoD Component, Preliminary Site Plan submissions shall include, at a minimum, the information specified below in subparagraphs C5.4.43.3.1. to C5.4.43.3.6. and C5.4.43.3.12. (If sufficient detail is available, the Preliminary and Final Site Plan Submissions can be combined into a Final Site Plan Submission.)

C5.4.43.2. Final. Final Site Plan submission shall include the information in subparagraphs C5.4.43.3.1. to C5.4.43.3.12.

C5.4.43.3. Site Plan Contents. A Site Plan should consist of:

C5.4.43.3.1. The DoD Component's approval, in the transmittal document, of the proposal, along with any changes, modifications, or specific precautionary measures considered necessary.

C5.4.43.3.2. Drawings, at a scale of 1 in equals not more than 400 ft or metric equivalent. (Smaller scale drawings may periodically be necessary to properly reflect certain distance and structure relationships within the area surrounding a given project.) When standard

drawings exist for a building or group of buildings that the DDESB has reviewed and declared acceptable (the Definitive Drawing), the drawing does not need to be resubmitted. In such cases, the site plan must note the Definitive Drawings for each building or structure to be constructed.

C5.4.43.3.3. The distances between the facility to be constructed or modified and all ES within QD arcs impacted by the project, to include on- and off-installation power transmission and utility lines; the installation's boundary; public railways; and public highways.

C5.4.43.3.4. A description of use and occupancy of each ES within IBD, *or the risk-based evaluation distance for risk-based site plans*, of the facility to be constructed or modified.

C5.4.43.3.5. The NEW ~~and for each AE~~ HD ~~of the AE~~ that will be stored or handled in the facility to be constructed or modified or that will impact the project.

C5.4.43.3.6. Anticipated personnel limits for the new or modified facility, to include a breakdown by room or bay, when appropriate.

C5.4.43.3.7. Approved drawings or, when approved drawings are not used, general construction details to include the following: materials used, dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, hazardous waste disposal systems, lightning protection system, static grounding systems, process equipment, and auxiliary support structures.

C5.4.43.3.8. A summary of the design procedures for any engineering protections that are to be used which the DDESB has not already approved. The summary shall include the following: a statement of the design objectives in terms of protection categories to be obtained (see Reference (j)), the explosives quantities involved, the design loads applied, any material properties and structural behavior assumptions made, references, and the sources of methods used. (Only engineers who are experienced in the field of structural dynamics and who use design procedures accepted by professionals in that field may design explosion resistant facilities.)

C5.4.43.3.9. Information on the type and arrangement of explosives operations or chemical processing equipment.

C5.4.43.3.10. A topography map, with contours (when terrain features are considered to provide natural barricading) or topography that otherwise influence the facility's layout, as in some chemical operations.

C5.4.43.3.11. When chemical agents are involved, also provide information on:

C5.4.43.3.11.1. Personnel protective clothing and equipment to be used.

C5.4.43.3.11.2. Treatment of all effluent and waste materials and streams.

C5.4.43.3.11.3. The adequacy of medical support.

C5.4.43.3.11.4. The average wind speed and direction.

C5.4.43.3.11.5. Other support facilities pertinent to chemical safety.

C5.4.43.3.11.6. The warning and detection systems to be used.

C5.4.43.3.11.7. Any hazard analysis performed.

C5.4.43.3.12. An indication of any deviations from pertinent safety standards that local conditions cause.

#### C5.4.43.4. Records

C5.4.43.4.1. The installation that submits the site plan shall maintain a copy of:

C5.4.43.4.1.1. The complete site plan and the final safety submission.

C5.4.43.4.1.2. A copy of the DDESB approval.

C5.4.43.4.2. Installations shall develop and maintain current (with the latest site plan approval) installation maps, and drawings that show QD arcs *or risk-based evaluation distances, as applicable*.

C5.4.43.4.3. Installations shall ensure that site plans are reconciled with the installation's Master Planning Documents.

#### C5.5. SITE PLANS NOT REQUIRED

Site plans are not required to be submitted to the DDESB for the specific situations listed below (DoD Components shall specify siting and documentation requirements for these situations):

C5.5.1. Storage and associated handling of HD 1.4S (see subparagraph C9.4.4.3.).

C5.5.2. Interchange yards limited to those operations described in paragraph C9.8.6.

C5.5.3. Inspection stations where only the operations described in paragraph C9.8.10. are performed.

C5.5.4. Parking of aircraft loaded with specific munitions (see subparagraph C9.6.1.1.2.2.) while in designated aircraft parking areas that meet airfield criteria, and associated handling of these munitions, provided the quantity of munitions involved in the operation is limited to a single aircraft load.

C5.5.5. The handling of HD 1.3 and HD 1.4 material ( $\leq 300$  lbs NEW) [ $\leq 136.1$  kg] necessary for ships' security and safety at sea (see subparagraph C9.6.2.1.2.2.).

C5.5.6. Storage of, *and operations involving*, limited quantities of HD 1.2.2, HD 1.3, or HD 1.4, for reasons of operational necessity, as permitted by subparagraph C9.4.2.10. and applicable notes of Tables C9.T13. and C9.T14.

C5.5.7. Certain contingency and combat training operations as described in section C10.3.

C5.5.8. Inert storage accessed by personnel related to the explosives mission.

C5.5.9. Locations used for a demilitarization processing operation of expended .50-caliber and smaller cartridge casings that meet subparagraphs C9.8.19.1. and C9.8.19.2., and are located outside of IBD from all PES.

*C5.5.10. Site and general construction plans or amendments to existing plans need not be submitted to the DDESB for facility modifications, mission changes, changes in operations, NEW increases, or HD additions that do not:*

*C5.5.10.1. Increase explosives safety or CA risks.*

*C5.5.10.2. Identify requirements for additional or increased explosives or CA hazard controls.*

*C5.5.10.3. Increase any QD arcs.*

*C5.5.11. Roll-on/roll-off (RORO) meeting the requirements of paragraph C9.8.12.*